BIG METER DATA ANALYTICS OF CITY-WIDE BUILDING PERFORMANCE FOR CLIMATE ACTION PLANNING

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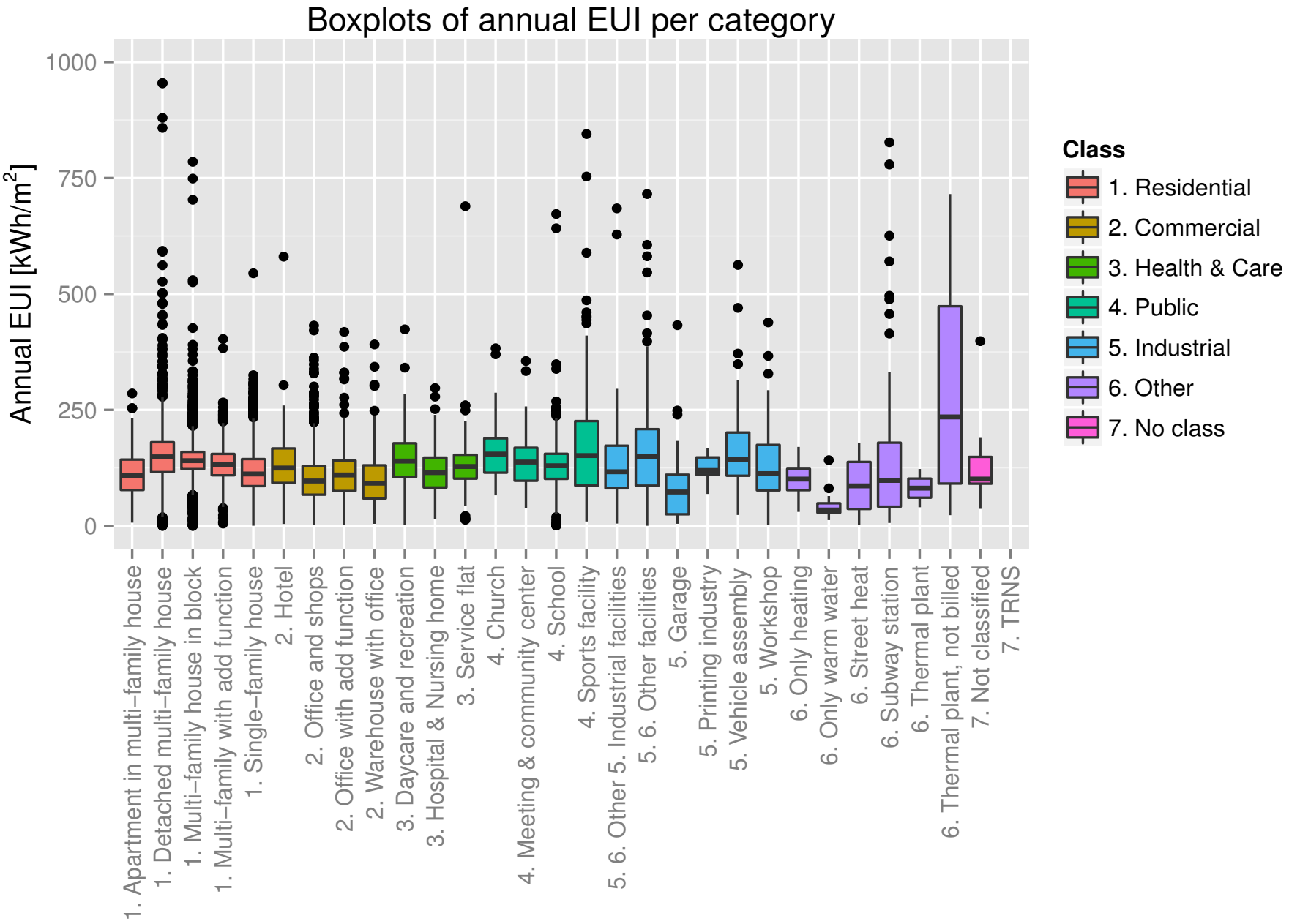
Purpose

- Challenges of the 21st century:
  - Growing population
  - Climate change
  - Energy security & sustainability
- Energy Efficiency Directive
- Stockholm action plan for climate and energy
  - Energy efficiency measures 2012-2015
  - Total energy consumption: -10%
  - Building energy consumption: -5%

Data

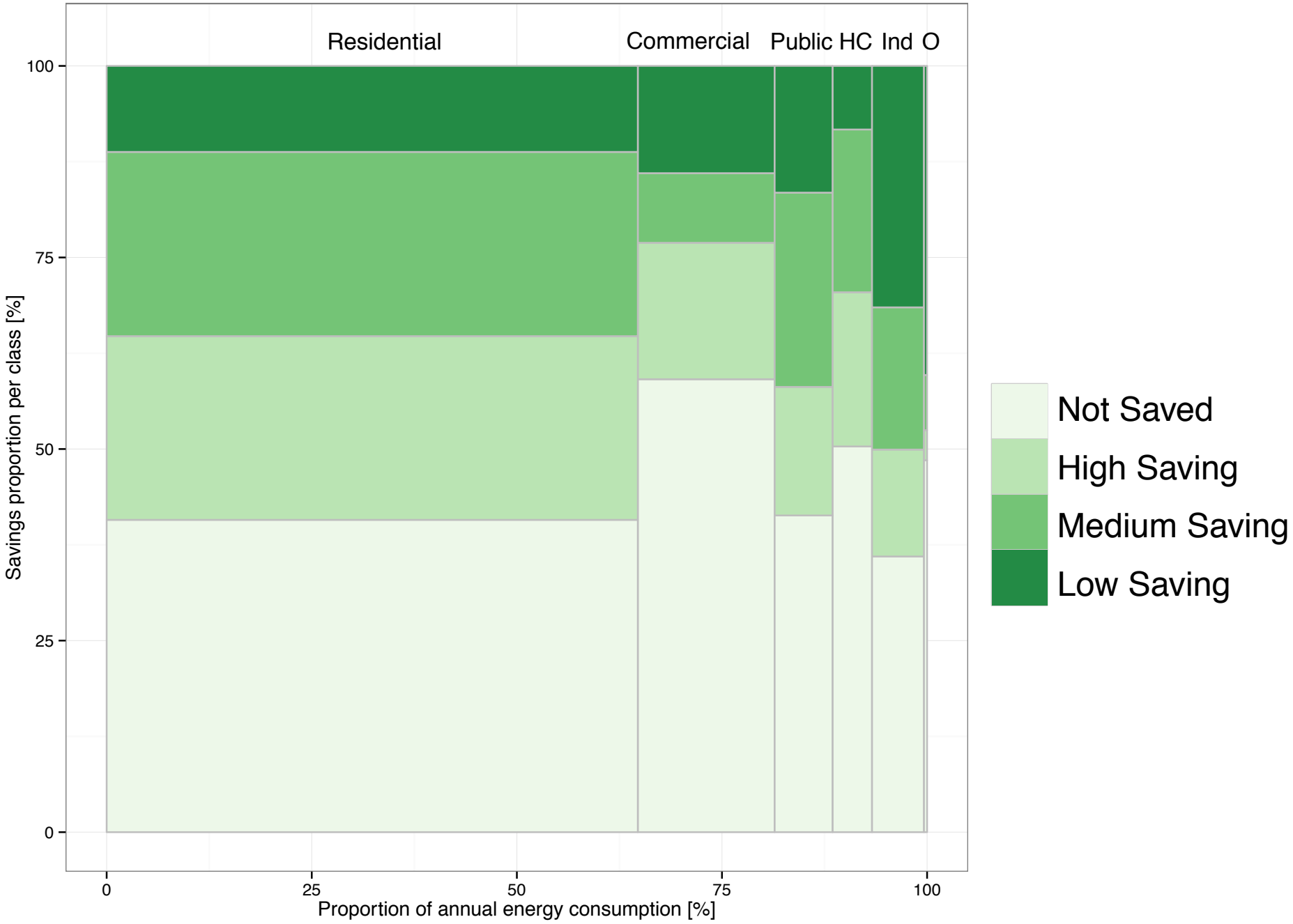
- Hourly meter data of heat consumption (for year 2012)
  - 15 000 building complexes
  - 47 600 000 m2
    - 6667 football fields
- Building characteristics
  - Type, age group, location
- 131 760 000 data entries
  - 4 y 65 days (at 1 entry per second)
  - 13 GB of raw data


Boxplots of annual EUI per category
Annual EUI [kWh/m2]
1000
750
500
250
0
1. Apartment in multi−family house
1. Detached multi−family house
1. Multi−family house in block
1. Multi−family with add function
1. Single−family house
2. Hotel
2. Office and shops
2. Office with add function
2. Warehouse with office
3. Daycare and recreation
3. Hospital & Nursing home
3. Service flat
4. Church
4. Meeting & community center
4. School
4. Sports facility
5. 6. Other 5. Industrial facilities
5. 6. Other facilities
5. Garage
5. Printing industry
5. Vehicle assembly
5. Workshop
6. Only heating
6. Only warm water
6. Street heat
6. Subway station
6. Thermal plant
6. Thermal plant, not billed
7. Not classified
7. TRNS
Class
1. Residential
2. Commercial
3. Health & Care
4. Public
5. Industrial
6. Other
7. No class

Method

- Calculations: KNIME, MatLab
- Retrofitting cost and saving estimates
  - Based on Stockholm Climate & Energy action plan
- Primary energy calculations
  - EED annex II

Technical potential



Efficiency measures

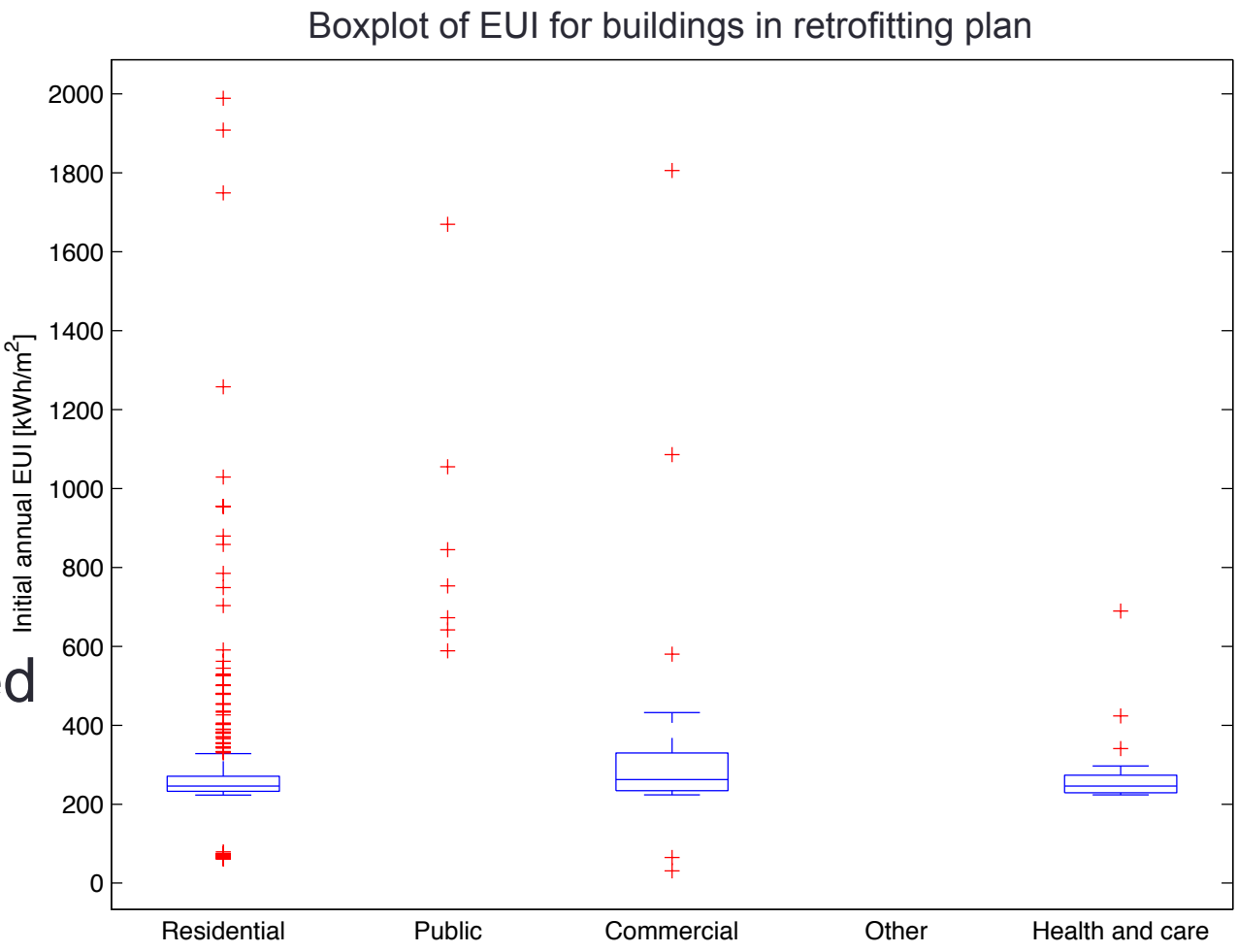
- Replace thermostats
  - -5% heating demand
  - low cost
- Install heat recovery ventilation
  - -33% heating demand
  - medium cost
- Renovate building climate shell
  - EUI limited to 60 kWh/m^2
  - high cost

- Application of measures depends on current EUI

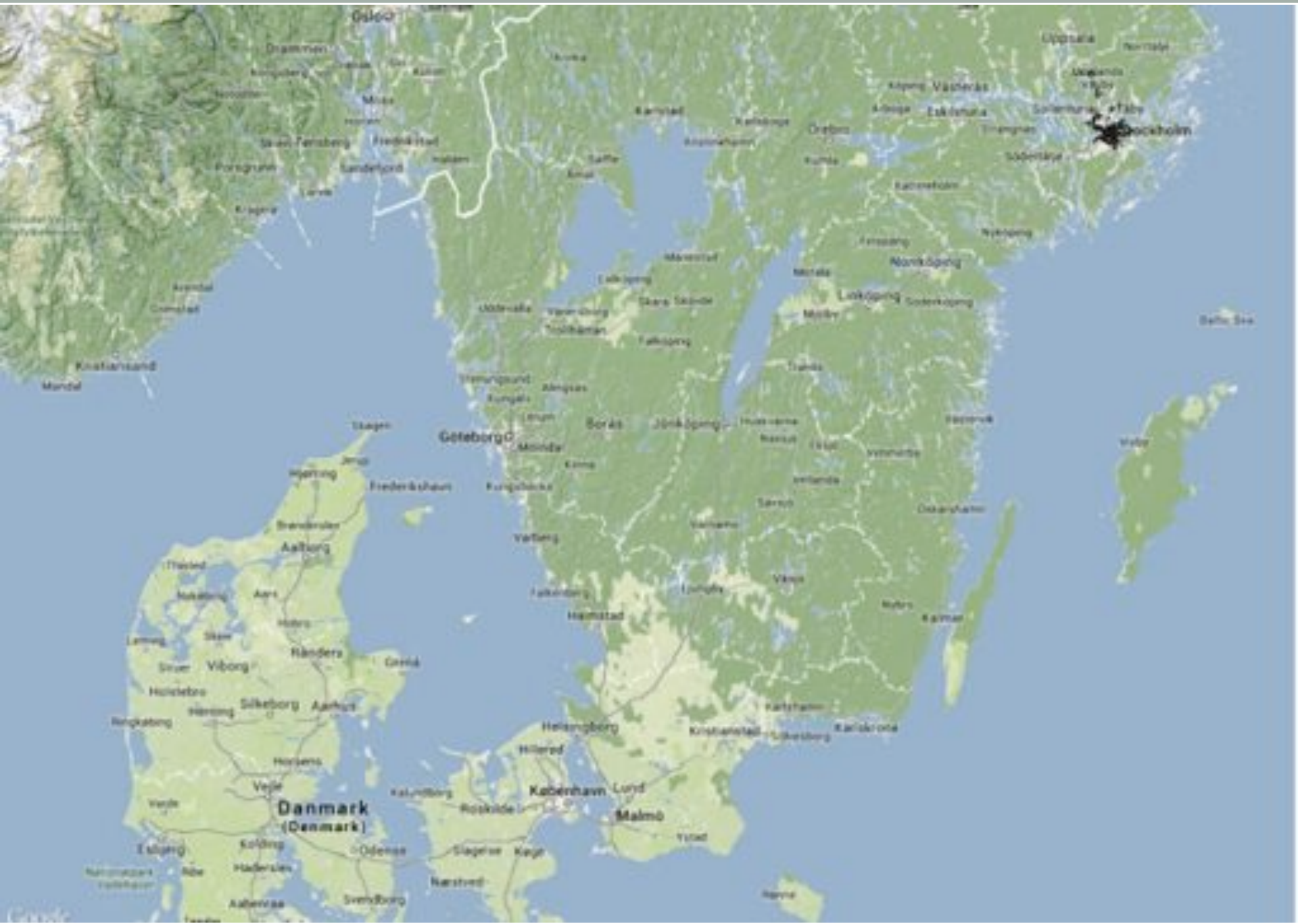
Resulting set of buildings for retrofitting plan

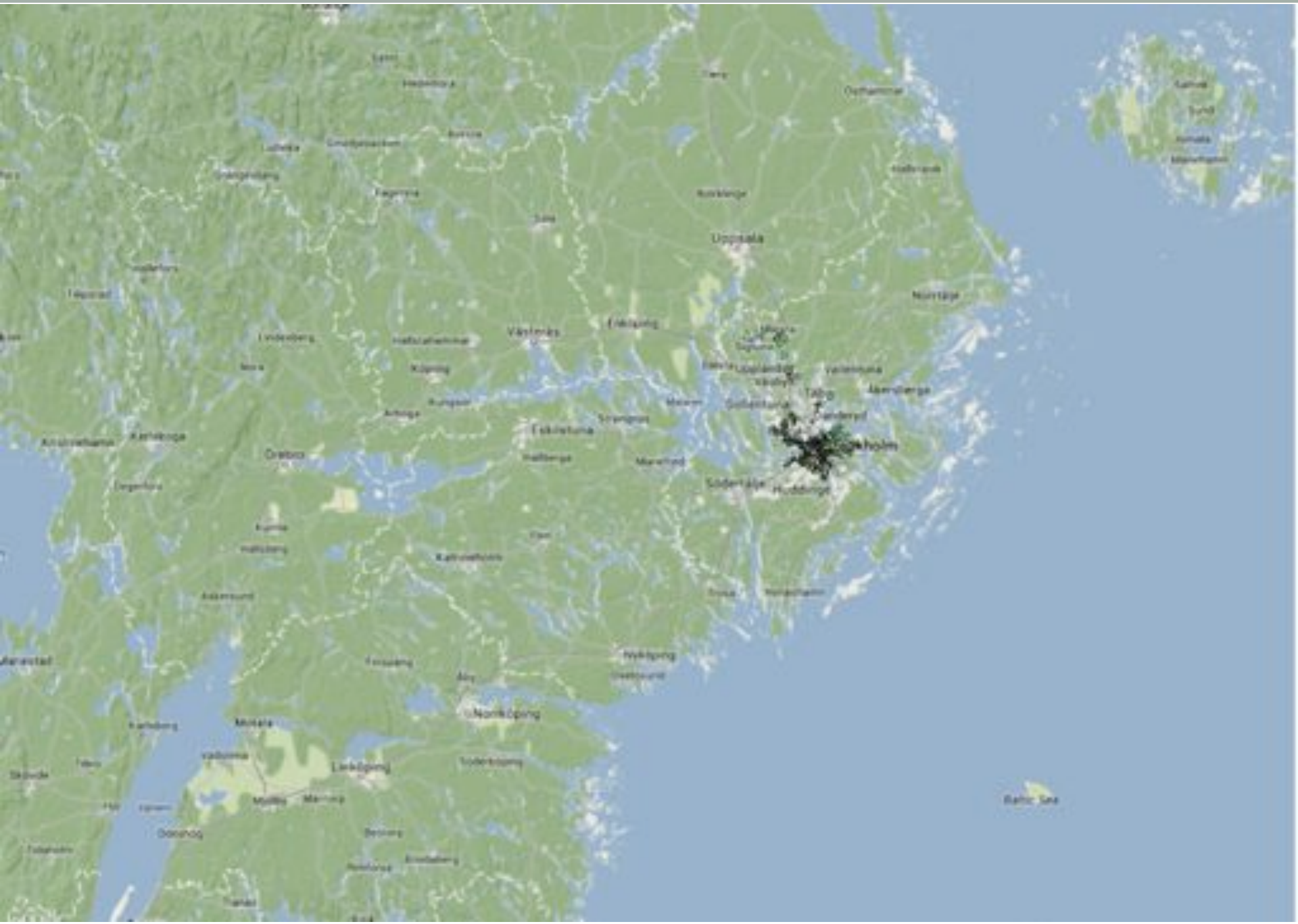
- Interest rate 4%
- Period 20y
- Positive NPV

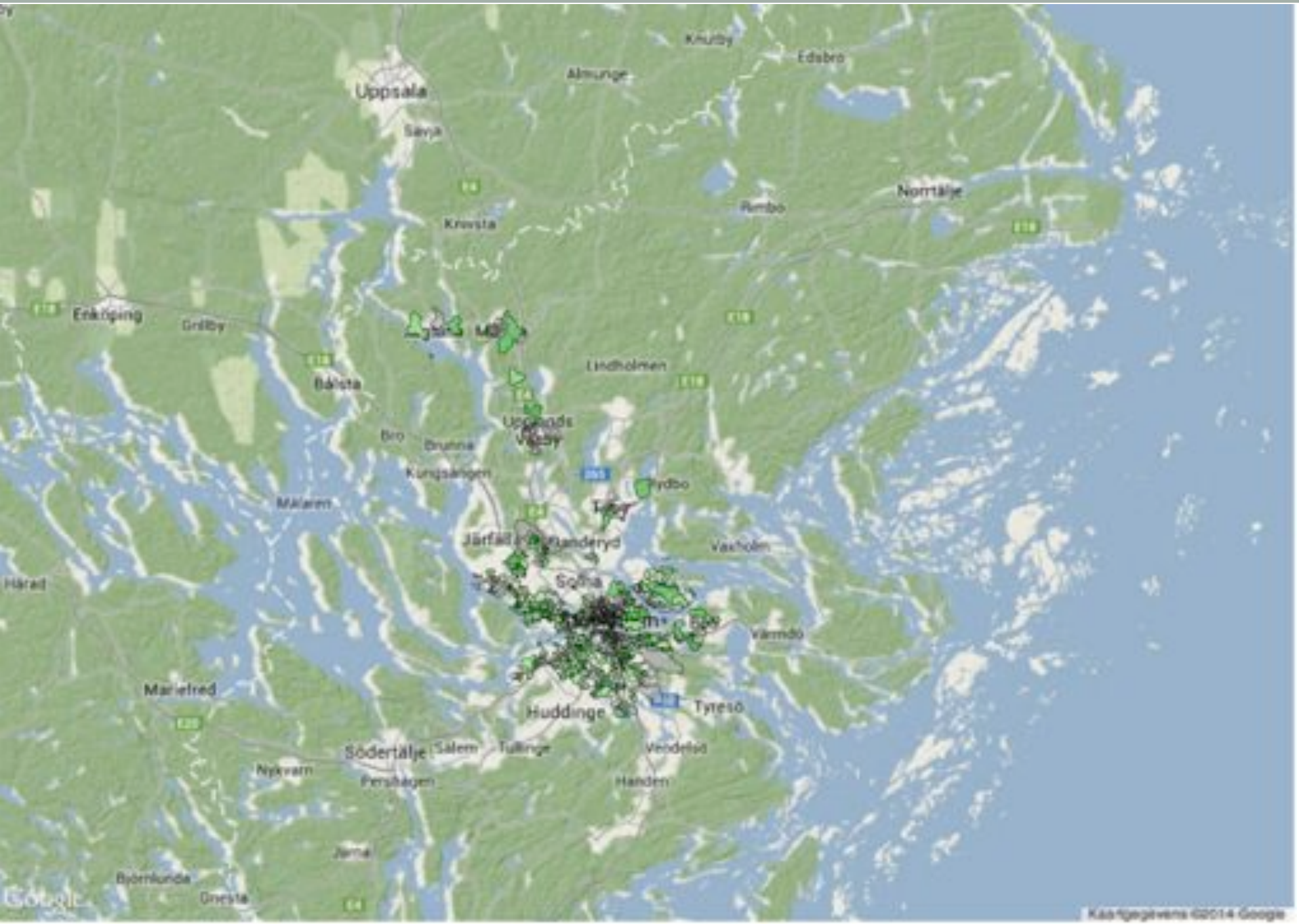
- 354 GWh
- 664 buildings
- 4.56% energy saved
- 37 GTCE saved




Norge
(Norway)
Danmark
(Denmark)
United
Kingdom
Ireland
Éire
Nederland
(Netherland)
Deutschland
(Germany)
Belgique
België
(Belgium)
Polska
(Poland)
Česká republika


Oslo
Drammen
Kongsberg
Moss
Fredrikstad
Sarpsborg
Sandefjord
Larvik
Kristiansand
Mandal
Arendal
Grimstad
Uddevalla
Trollhättan
Vänersborg
Lidköping
Skara
Skövde
Falköping
Mariestad
Karlstad
Kristinehamn
Örebro
Kumla
Hallsberg
Katrineholm
Eskilstuna
Strängnäs
Södertälje
Västerås
Köping
Arboga
Uppsala
Stockholm
Nyköping
Norrköping
Motala
Linköping
Söderköping
Mjölby
Tranås
Jönköping
Huskvarna
Nässjö
Vetlanda
Värnamo
Sävsjö
Oskarshamn
Västervik
Visby
Gotland
Borås
Mölndal
Kungälv
Lysekil
Uddevalla
Strömstad
Halmstad
Varberg
Falkenberg
Laholm
Hässleholm
Ystad
Kristianstad
Karlskrona
Karlshamn
Olofström
Kalmar
Växjö
Ljungby
Helsingborg
Hörby
Lund
Malmö
København
Roskilde
Kalundborg
Slagelse
Kalundborg
Næstved
Odense
Svendborg
Nyborg
Kolding
Esbjerg
Vejle
Horsens
Silkeborg
Aarhus
Randers
Viborg
Holstebro
Skive
Aalborg
Thisted
Frederikshavn
Skagen
Danmark
(Denmark)


Uppsala
Västerås
Eskilstuna
Örebro
Nyköping
Norrköping
Linköping
Motala
Mjölby
Oskarshamn
Nynäshamn
Baltic Sea


Uppsala
Almunge
Knivsta
Norrtälje
Enköping
Gnesta
Lindholmen
Bålsta
Bro
Kungsängen
Järfälla
Vaxholm
Södertälje
Nykvarn
Huddinge
Tyresö
Marietred
Haninge
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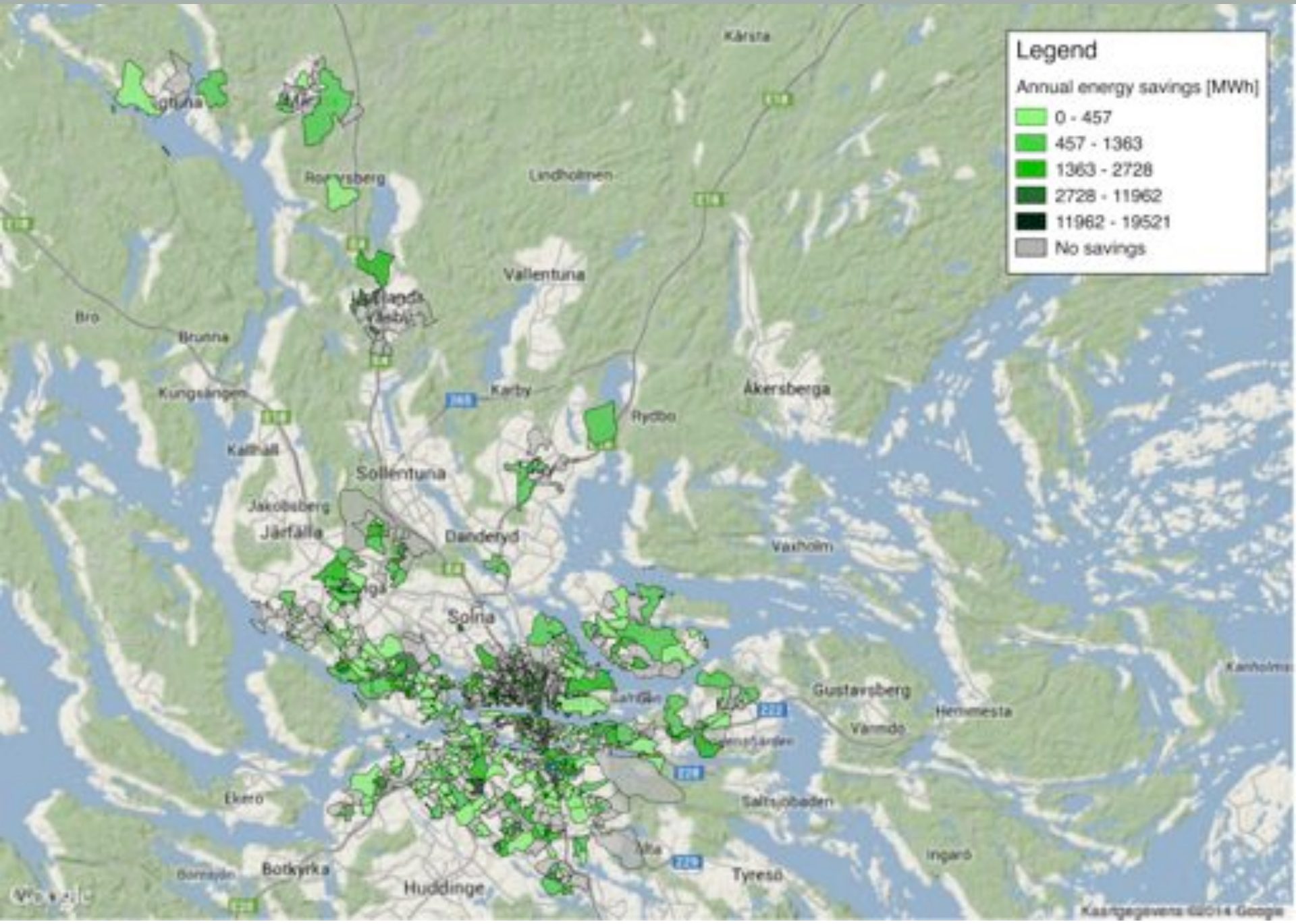
Legend
Annual energy savings [MWh]
0 - 457
457 - 1363
1363 - 2728
2728 - 11962
11962 - 19521
No savings
Kärsta
Lindholmen
Vallentuna
Bro
Brunna
Kungsängen
Karby
Rydbo
Åkersberga
Kallhäll
Sollentuna
Jakobsberg
Järfälla
Danderyd
Vaxholm
Solna
Gustavsberg
Hemmesta
Vaxholm
Ekero
Saltsjöbaden
Ingarö
Botkyrka
Huddinge
Tyresö
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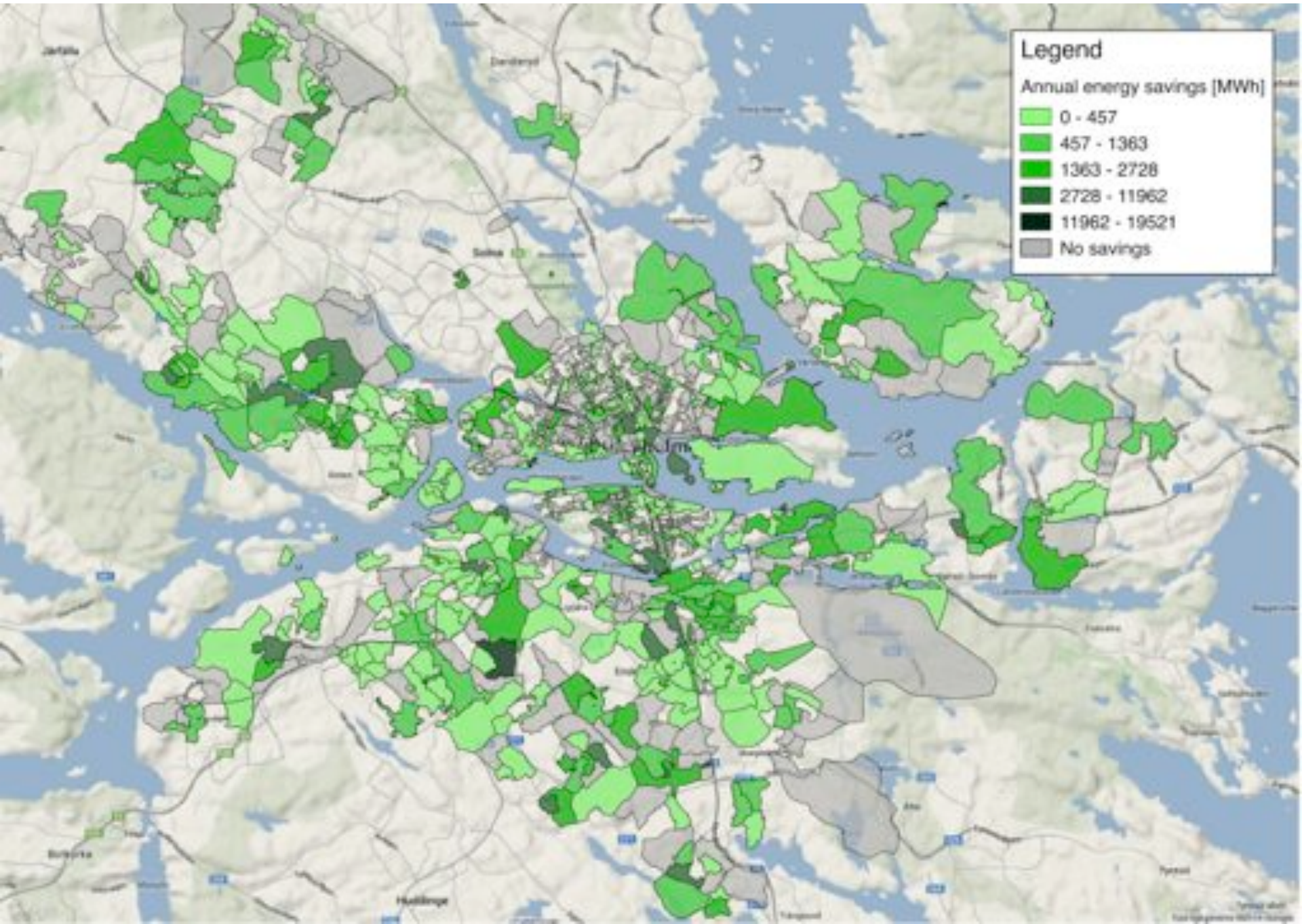
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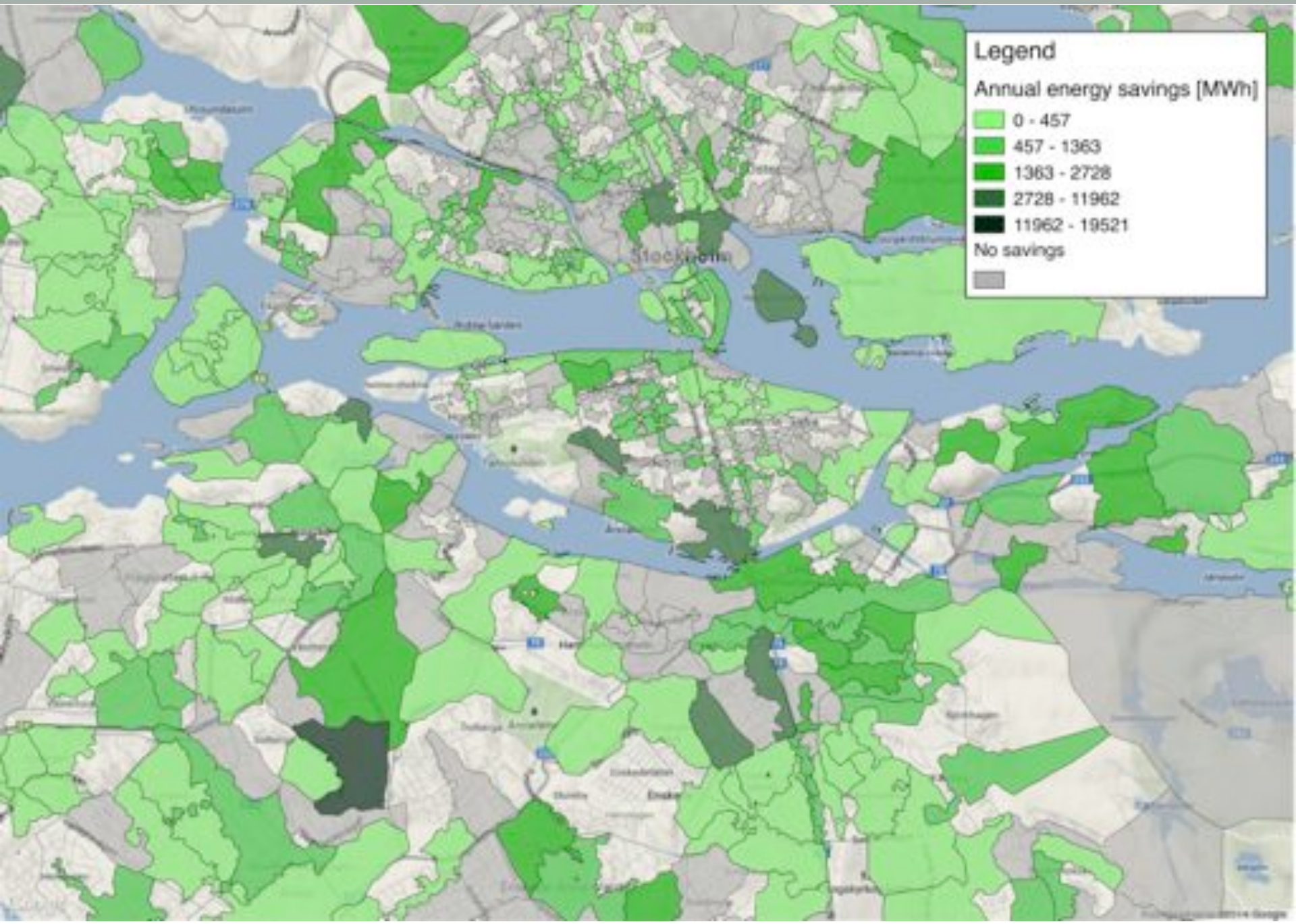
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Conclusions

- City goals can nearly be reached with NPV > 0
- Total potential corresponds to 49% (3.83 TWh/a)
- Investment cost € 8.7 billion (£ 7 billion)
- € -3.3 billion NPV (4%) (£ -2.7 billion)
  - € -5.3 billion NPV (10%) (£ -4.2 billion)